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भाग 7 अग्नि संरक्षण पहलू

(पहला पुनरीक्षण)

Construction, Operation and Maintenance of River Valley Projects — Safety Code

Part 7 Fire Safety Aspects

(*First Revision* **)**

ICS 93.160

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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Safety in Construction, Operation and Maintenance of River Valley Projects Sectional Committee, WRD 21 had been approved by the Water Resources Division Council.

A continuous supply of electric power is of primary importance for almost all human activities, particularly in the industrial sector. Outbreak of fire or an explosion in a power station may completely curtail supply of electrical power for considerable time in addition to causing extensive damage to the building and equipment.

Importance of fire safety, for electrical generating and distributing stations has been increasingly recognized, due to occurrence of several devastating fires in such locations in the recent past. Therefore, considering the fact that any fire in such installations may completely disrupt the life of the community, several industries served by them, and may also involve replacement of highly valuable equipment, it is necessary that every attempt should be made to prevent or at least minimize, the occurrence and spread of fires in these installations. Installation of equipment having built-in safety measures in the premises and judicial suppression or isolation of fire risks will therefore reduce both frequency of outbreaks of the fire as well as curtail the possibility of its spreading to other areas. Further, with the adoption of suitable fire safety norms with regard to design, layout and construction of buildings and other structures, choice of materials for construction, etc, the premises can be rendered safer from the point of view of fire risk.

The important fire safety and fire protection requirements for a power plant which should receive due attention are given in this standard. Where necessary, reference to relevant Indian Standards has also been made. Any fire safety measures other than those covered in this standard, if prescribed in the relevant statutory rules and regulations, should also be adhered to. Requirements in respect of first aid and other emergency medical relief are not covered in this standard.

This standard was first published in 1993; however, the Committee responsible for the formulation of this standard decided to revise it based on the experience gained since then as well as considering technological development in the field.

The composition of the Committee responsible for the formulation of this standard is given in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

CONSTRUCTION, OPERATION AND MAINTENANCE OF RIVER VALLEY PROJECTS — SAFETY CODE

PART 7 FIRE SAFETY ASPECTS

(First Revision)

1 SCOPE

1.1 This part lays down the fire safety requirements in river valley projects covering the following components and aspects:

a) Main components, such as dams, canals, tunnels, penstocks, control structures, valve houses, distribution stations, transformer and switch yards.

b) Buildings both permanent and temporary.

c) Forest - Where most of the river valley projects are located either in hills or foot hills.

d) Hydropower stations and their allied equipment.

1.2 This standard is intended to be of use during the construction, operation as well as maintenance periods, for the fire safety of river valley projects. Utmost care should be taken in fire precautions during the construction time of the project as it is the busiest period for various activities and on account of large deployment of men and material.

2 REFERENCES

The Indian Standards listed below contain provisions which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on these standards are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
636 :2018	Specification for non-percolating flexible fire fighting delivery hose (*fourth revision*)
941 : 1985	Specification for blower and exhauster for fire fighting (*second revision*)
944 : 1979	Functional requirements for 1800-1/ Min trailer pump For fire brigade use (*second revision*)
949 : 2012	Emergency (Rescue) Tender — Functional Requirements (*third revision*)
950 : 2012	Functional Requirements for water tender, type B for fire brigade use (*third revision*)
951 : 2003	Functional Requirements for crash fire tender for air fields (*fourth revision*)
1641 : 2013	Code of practice for fire safety of buildings (general): General principles of fire grading and classification (*second revision*)
1642 : 2013	Fire safety of buildings (general): Details of construction — Code of practice (*second revision*)
1643 : 2013	Code of practice for fire safety of buildings (general): Exposure hazard (*second revision*)
1644 : 2013	Code of practice for fire safety of buildings (general): Exit requirements and personal hazard (*second revision*)
1646 : 2015	Code of practice for fire safety of buildings (general): Electrical installations (*third revision*)
2097 : 2012	Foam making branch pipe and foam inductor — Specification (*second revision*)
2175 : 1988	Specification for heat sensitive fire detectors for use in automatic fire alarm system (*second revision*)
2189 : 2008	Selection, installation and maintenance of automatic fire detection and alarm system — Code of Practice (*fourth revision*)
2190 : 2010	Selection, installation and maintenance of first-aid fire extinguishers — Code of Practice (*fourth revision*)

IS No.	*Title*
2871 : 2012	Branch pipe, universal for fire fighting purpose — Specification (*second revision*)
3594 : 1991	Code of practice for fire safety of industrial buildings: General storage and warehousing including cold storage (*first revision*)
3844 : 1989	Code of practice for installation and maintenance of internal fire hydrants and hose reels on premises (*first revision*)
4571 : 1977	Specification aluminium extension ladders for fire brigade use (*first revision*)
4927 : 1992	Unlined flax canvas hose for fire fighting - specification (*first revision*)
4989 : 2018	Foam concentrate for producing mechanical foam for fire fighting — Specification (*fourth revision*)
6070 : 1983	Code of practice for selection, operation and maintenance of trailer fire pumps, portable pumps, water tenders and motor fire engines (*first revision*)
9668 : 1990	Provision and maintenance of water supplies and fire fighting - Code of practice (*first revision*)
10993 : 1984	Functional requirements for 2000 kg dry powder tender for fire brigade use
11006 : 2011	Flash back arrestor (flame arrestor) — Specification (*first revision*)
12459 : 1988	Code of practice for fire safety in cable runs
12717 : 1989	Fire fighting equipment — High capacity portable pumpset (1 100 - 1 600 l/min) — Functional requirements
12777 : 1989	Method for classification of flame spread of products
12835 (Part 1) : 1989	Design and installation of fixed foam fire extinguishing system — Code of Practice Part 1 Low expansion foam
13039 : 2014	External hydrant systems - provision and maintenance — Code of practice (*first revision*)
15325: 2020	Design and installation of fixed automatic high and medium velocity water spray system — Code of Practice

3 GENERAL

3.1 A fire outbreak in any part of a river valley project assumes the greatest importance because of the following factors:

a) Except for large network of canals and tunnels, other components, such as storage dams, power house, transformer yard, storage yard and residential camps are mostly located relatively close to one another.

b) Generally, the peak period of activity in a project starts after one year of the beginning of the project and ends one year ahead of completion of the project. A number of temporary structures, both residential and non-residential exist in the area with a large number of human beings occupying them. Hence, there is a possibility of outbreak of fire with the chances of its spreading being greater. Other components of the project are generally constructed with concrete/masonry and steel, duly following the precautionary measures of fire safety as per standards. Hence the possibility of outbreak of fire in these structures is comparatively rare but cannot be ruled out completely.

3.2 The main fire risk areas in a hydropower station are:

a) Turbo generators including lubricating and oil systems.

b) Oil fueled generator, station, unit and auxiliary transformers including associated coolers and conservator tanks.

c) Diesel driven pump/engine units and their fuel and storage tanks.

d) Hydrogenerators and their allied equipment, such as unit transformers, auxiliary transformers, AC/DC distribution and control boards, AC/DC power and control cables, etc.

e) Cable gallery within power house as well as cable gallery from power house to switchyard.

f) Oil storage tank room used for storing of transformer oil for its dehydration during capital maintenance of generator transformer.

g) Lubricating oil system and electrical system in valve house.

h) Control room.

3.3 The distribution stations such as load dispatch centres and sub-stations also present fire hazards arising from oil filled transformers, switchgear, cable galleries/tunnels, etc.

3.4 The fire protection coverage for power plants should be comprehensive in catering to all the fire hazards as mentioned above. The planning for the fire protection schemes should start right from the design stage of

the plant, thereby ensuring that adequate and suitable fire protection measures, both active and passive are incorporated not only while finalising the plant design itself, but also right up to the completion stage.

3.5 In the fire protection system for the power plant, due consideration should be given to the danger of smoke logging in all locations in addition to safeguarding against other likely gaseous and toxic products. The provision of adequate means of escape should also be given due consideration in the interest of safety to life (*see* IS 1644).

3.6 Each installation shall prepare a detailed 'Fire emergency procedures' manual outlining the actions to be taken by each personnel during a major incident for use by the organization and this manual shall be available to all personnel in the installation. The fire emergency procedures including firefighting plan should be prepared for fighting fires in process area, storage tanks, Electrical fire, building fire, etc.

4 COMMUNICATIONS

4.1 Reliable communication system for various components of the river valley project among themselves and with fire fighting stations, etc, are vital as fire fighting personnel have to get mobilized and move into action within the shortest possible time, before the situation worsens.

4.2 Communication systems should be reliable and will have to be maintained perfectly in view of the fact that the components of the river valley projects are located mostly in remote and isolated areas.

4.3 Fire alarms (automatic and manual) and sirens should be installed at suitable important locations for local alerts.

4.4 Provision for announcement of fire on the loud phones installed at various locations of the power plant should also be made.

4.5 Telephone numbers of emergency responders that is Fire Station, Ambulance, Forest Officers, Plant Incharge, etc, should be prominently displayed at vulnerable locations.

4.6 CCTV should be provided for all the remote/isolated locations. Display of the same should be available at control room for monitoring.

5 FIRES IN FOREST

5.1 When a forest fire starts, it is quite small in extent and not noticed till it develops significantly and becomes wide spread. A fully developed fire is difficult to extinguish or control. Hence, precautions should be taken, not only for preventing start of fires, but also for extinguishing them, so that the components of the structures in hydro projects are not affected in a big way.

5.2 Prevention

Trespassers and people, who visit forests on picnics, should be warned about the danger of creating fires by careless and indiscriminate actions. Suitable warning boards should be exhibited at a number of places.

Observation towers are erected in forests by the forest department for various purposes. The spacing of such observation towers should be made closer in forests where components of hydro projects are sited. There should be good liaison between the authorities of the hydro projects and the forest department in the exchange of information about fire for their mutual safety.

In many projects, it is now mandatory to provide for compensatory afforestation. Such compensatory afforestation should not be made in close proximity of the various components of the hydro projects. Generally, extensive cultivation, plantation or compensatory afforestation should not be allowed within a distance of 30 m from the components of hydro projects.

5.3 Fire Extinguishment

If the fires are observed during early stages, they can be extinguished by beating. A number of personnel in the hydra projects should be trained for undertaking the beating operation in a systematic way. Such personnel may be trained by the staff of the forest department.

Fire barriers may be created at close intervals so as to contain fire in a limited area and concentrate on the efforts for extinguishing the fire.

Proper use of water can extinguish many fires effectively and also contain their spread. Facility for adequate supply of water should be created in the fringe areas of the components of hydro projects, adjoining the forest areas. The personnel in hydro projects should be trained in the use of water for extinguishing and preventing the spread of fires.

When a fire is noticed in the forest, the nearby fire station should be immediately alerted by instantaneously communicating with them, as it is advisable to get trained fire personnel and fire fighting equipment to the danger area at the earliest.

6 BUILDING CONSTRUCTION AND RELATED REQUIREMENTS

6.1 The structural elements of all buildings of an electrical generating/distributing station should be of Type 1 construction, complying with the requirements of IS 1642.

6.2 Smoke Ventilation

Provision for ventilation of smoke and toxic gases from a fire within the power station building, preferably of

automatic type, should be made over the generator floor to permit escape of heat, toxic gases and large volumes of smoke likely to be generated. The requirements of fire venting should conform to the provisions contained in Annex B of Part 4 of the National Building Code 2016. For extraction of smoke from fire a minimum air change rate of 12 per hour be obtained depending on fire load, room height, size, etc. In case the start of smoke extraction is delayed, the volume change rate may have to be increased even up to 30 changes. Smoke vents of approved design, preferably automatic, should be incorporated in cable tunnels/galleries, turbine halls, plant rooms, switch board rooms, etc, and provision made for the attachment of portable extraction units, if not already served by a fixed smoke extraction installation.

6.3 To achieve compartmentisation, the plant should be subdivided into individual fire areas to the maximum feasible extent, so as to reduce the spread of fire from one area to another area and the consequential damage, and also to achieve easy control and extinguishing of the fire. Such compartment by fire barriers, or separation walls of minimum 2 h fire resistance, should be provided in the following cases:

a) Where a turbine hall houses more than one unit, a fire barrier/separation wall should be provided for each unit beneath the operating floor in the turbine and electrical bays.
b) Between turbine generator hall and control room/ computer room/instrument room.
c) Between turbine generator hall and Electrical Switchgear room (unit wise barriers needed).
d) Between the turbine generator hall and cable galleries (unit wise barriers needed).
e) Between staircases and lift shafts and the rest of the building.
f) Flammable liquids should be stored separately away from the work area.
g) Between transformer yard/outdoor transformers and any other nearby building, in case a clear distance of 15 m is not available.
h) Between indoor transformers where a clear distance of 15 m is not available.
j) Between individual oil-filled transformers containing oil in excess of 2 000 litre, in case clear distances as specified in IS 1646 are not maintained.
k) Between battery rooms and other adjoining areas.
m) Between cable galleries of each unit.
n) Within cable galleries.

6.4 The door provided in the separation walls between these fire areas should be self-closing, fire-check doors of fire rating equal to that of the separation wall.

6.5 Windows/ventilators in fire separation walls (for example for control rooms or computer rooms) should be preferably provided with clear fire resisting glass of minimum 45 min fire resistance or with automatic fire resistance/shutters or an automatic water curtain.

6.6 Cellular or foamed plastic materials (such as expanded Polystyrene, polyurethane foam, etc) should not be used as interior finish or insulation in any part of the building. Where interior finishes (wall, linings. false ceilings, etc) are unavoidable they should be non-combustible of Class I flame spread (*see* IS 12777).

6.7 Air conditioning for the control room should provide a pressurized environment to preclude the entry of smoke in the event of a fire outside the control room.

6.8 Plastic ducts, including 'fire retardant' types, should not be used for ventilating systems.

6.9 Provision should be made in all fire areas of the plant for removal of all liquids, including fire fighting water, directly to safe areas. The drainage facilities (pits, sumps and sump pumps) should be adequate to cater to all of the following emergencies;

a) The spill of the largest single container of any flammable or combustible liquids or both, in the area;
b) A minimum flow of 1 800 lpm for fire fighting operations, for at least 20 min; and
c) The maximum design volume of discharge from fixed fire suppression system(s) operating for a minimum of 20 min.

NOTE — The provision for drainage and any associated drainable facilities (pits, sumps, drains to downstream surge chamber and/or tail tunnel or tail race, and sump pumps) for underground power plants should be sized to accommodate to discharge from the maximum expected discharge of the fixed fire suppression system(s) operating for a minimum of two hours.

6.10 Floor draining from areas containing flammable or combustible liquids should incorporate suitable flame traps or flame arrestors, conforming to IS 11006.

6.11 Switchgear, oil-circuit breakers and transformers should be preferably housed in detached single storey buildings of Type 1 construction (*see* IS 1642).

6.12 The building used for storage purposes should conform to the requirements of IS 3594.

6.13 The safety distance separating various buildings should be according to IS 1643 and the exit requirements should conform to IS 1644.

6.14 Distance separating fuel oil storage tanks, open storage oil drums, etc, should be in accordance with the relevant statutory requirements as given in Petroleum Rules, 2002.

6.15 The switch yards should be provided with lightning protection conforming to IS/IEC 62305.

7 POWER STATION FACILITIES

7.1 Generator Units

7.1.1 Major fire risks in turbo generators arise from the leakage, or escape, of combustible lubricating and hydraulic fluids contained in the lubricating or governor seals, and jacking oil systems. The risk normally extends to the floor areas which house the lubricating systems and within the radius of an oil spray pattern cascading from a failure of bearings in the oil supply headers.

7.1.2 A bund wall should surround and contain the main lubricating oil, jacking oil and flushing oil package unit area, to prevent spread of oil to surrounding floor areas.

7.1.3 Concrete or concrete protected steel should be used for the supporting structure of turbine generator units. Exposed steel construction is acceptable, if protected by an automatic deluge sprinkler system.

7.2 Oil Risks

7.2.1 The risks arise from an escape of combustible lubricated and hydraulic fluids contained in the system, which can be considerably reduced by using completely separate circuits for the lubricating system and the control system.

7.2.2 The seal oil and jacking oil systems are also subject to the same risks.

7.2.3 There should be arrangement for collecting of lubricating oil from the distribution pipes by adopting any one of the following methods;

a) By running the oil lines in concrete lined tunnels/ trenches, or steel-lined troughs, specially provided for the purpose or
b) By employing the double pipe system, that is running the pressurized supply pipe inside a concrete larger pipe acting as a leakage collector, which should also act as a return pipe

8 ELECTRICAL INSTALLATIONS AND EQUIPMENT

8.1 General Requirements

8.1.1 The electrical installations and equipment of the power station should conform in all respects to the relevant guidelines given in IS 1646.

8.1.2 Gasoline, benzene, ether, alcohol, similar flammable cleaning fluids and water should not be used on energized electrical apparatus. The use of such flammable cleaning fluids on de-energized apparatus may, however, be permitted provided the apparatus is not energized within half an hour of such use.

8.1.3 None of the flammable solvents mentioned in **8.1.2** should be used in the vicinity of electrical equipment from which sparks may be received.

8.1.4 All electrical equipment should be kept absolutely free of deposits of oil, grease, carbon dust, etc.

8.1.5 All electrical equipment should be effectively earthed at atleast two points to avoid any flash/spark.

8.1.6 Electrical equipment shall be regularly inspected and tested to prevent chances of fire. Precautions to be taken for safety of electrical installations confirming to relevant standards/ OEM recommendations.

8.2 Cables and Cable Galleries

8.2.1 The fire protection requirements for cable galleries cable runs, etc, should conform to the provisions contained in IS 12459, including the fire protection requirements such as segregation of cable runs into compartments, use of fire resistant cables in critical areas and groups of cables and sealing of penetration openings in the walls and floors.

8.2.2 In addition to the usual cable clamps above floor level, cables should also be clamped immediately below floor level. Each cable or group should, where possible, be protected by a pipe or cover of heat resisting material rising to a height of at least 450 mm above floor level, or terminating just below the cable gland, sealed at the bottom and filled with sand or small pebbles.

8.2.3 Whenever possible, all jute shavings should be removed from cables in switch rooms, basements and tunnels.

8.2.4 Where cables rest on the floor of tunnel or basements, they should be separated into groups by vertical barriers of tile, brick or concrete and the trenches so formed should be filled with small pebbles. Alternatively, the cables may be separately clamped and each cable group should be separated by a minimum clear space of 75 mm.

8.2.5 Power cables and control cables should run in separate trenches, wherever possible.

8.2.6 Emergency lighting shall be provided inside the cable gallery and cable tunnels.

8.2.7 Fire stops should be deployed at the locations where the trenches enter the sub-station.

8.3 Transformers

All transformer installations should comply with the provisions of IS 1646 in addition to the following:

a) As a protection against excessive damage due to occurrence of faults, transformers fitted with conservators should be protected with Bucholz relay.

b) All other transformers should be equipped with oil temperature alarms or excess current relay protection.

c) The level and dielectric strength of the transformer oil should be checked at periodic intervals and in the event of presence of a large quantity of sludge, the oil shall be reconditioned/ replaced.

d) Diagnostic devices like PD monitoring system etc shall be provided to read the health of transformers with capacity 20 MVA and above.

e) Differential protection should be provided for transformers rated 5 MVA and above.

f) Transformers connected to Grid supply should have 'ON LOAD TAP CHANGERS' for control of secondary voltage.

8.4 Battery Room

8.4.1 Motor generator sets and/or converter or rectifiers together with necessary switches and control gear should be mounted separately (preferably in separate rooms as far as possible) and away from the batteries.

8.4.2 The storage batteries and all attendant equipment, except compact metal clad units, should be mounted away from all other apparatus, in a location free from dust, and should be well ventilated.

8.4.3 The batteries should stand directly on durable, non-ignitable, non-absorbent and non-conducting material, such as glass, porcelain or glazed earthenware. These materials should rest on a bench which should be kept dry and insulated from earth. If constructed of wood it should be slatted and treated with anti-sulphuric enamel and coated with fire resistant paint.

8.4.4 The batteries should be so arranged on the bench that a potential difference exceeding 12 V should not exist between adjoining cells. Batteries exceeding 20 V should not be bunched together or arranged in a circular formation.

8.4.5 All combustible materials within a distance of 60 cm measured horizontally, or within 2.0 m measured vertically, from any battery, should be protected with hard asbestos sheets.

8.4.6 The charging circuit should be provided with miniature circuit breakers of suitable rating. Where a motor generator is employed, the motor should be provided with double or triple pole switches and fuses and an automatic battery and cut-out should be placed in the generator circuit. Any subcircuit should be provided with a fuse rated not more than 7 A in each live conductor.

8.4.7 The charging control panels should be of durable, non-ignitable non-absorbent, non-conducting material and together with rectifiers, transformers and supports for resistance of lamps, should be on a bench which should be kept dry and insulated from earth. If constructed of wood, it should be slatted and treated with anti-sulphuric enamel and painted with fire resistant paint.

8.4.8 If batteries are charged through resistance or lamps, unless these are enclosed in metallic enclosures, they should be at least 60 cm away from the nearest battery.

8.4.9 All permanent wiring should be securely run and protected against mechanical injury. Efficient terminals or connections should be used from which connections to batteries can be made. Rubber insulated wiring or any other type of combustible insulated wiring, if on insulators, should not be run in such a position that a fire arising at any battery could reach it. All conductors connecting the supply terminals to batteries should have either rubber or tough compound insulation without tape or braid.

8.4.10 If the source of supply in the mains has one conductor earthed, the lamps or other resistance should be connected on an earthed lead and the batteries connected direct to earth conductors.

8.4.11 No celluloid cased storage batteries should be used.

8.4.12 All china clay or other insulators should be kept free of dust, and all casings, conduits, wood or metal work likely to be affected by acid spray or fumes should be protected by acid resisting paint, varnish or compound. All exposed current carrying bus shall be insulated and terminals coated with petroleum jelly

8.4.13 The housing of the batteries should be well ventilated to prevent build-up of flammable atmosphere and all electrical accessories should be flame proof..

8.4.14 No switching operation should be allowed inside battery room. All normal/ industrial type switches should be located outside battery room.

8.4.15 Floors and walls (up to 1 m height) should be lined with acid proof tiles or coated with acid resistant paint.

8.4.16 Eyewasher/shower should be provided in battery bank room.

8.4.17 All battery banks shall be routinely checked for healthy cell voltage, specific gravity of cells, electrolyte level, etc.

9 ILLUMINATION

9.1 The illumination levels in different areas shall be as per good engineering practice. Minimum illumination levels for various areas should be as per IS 6665/ OISD-RP-149

9.2 Storage godowns and warehouses shall be illuminated as per provisions of IS 3594.

10 FIRE PROTECTION MEASURES

10.1 General

10.1.1 Generating stations may vary in size from small capacity stations to large multi unit power stations including super power stations. Electrical generating and distribution stations come under the occupancy classification of Industrial Buildings, G-3 (*see* IS 1641).

10.1.2 The extent and nature of the fire protection measures as well as exit facilities to be provided will depend on various factors like size and location of the station, risks involved, availability of outside help for major fire fighting, etc. However, all the power stations, irrespective of their size, should provide for adequate fire protection/fire fighting arrangements and exit facilities.

10.1.3 Most of the hydropower stations are located in relatively remote areas with hardly any other assisting fire service within a reasonable distance. Such isolated locations make it all the more necessary for power stations to have an independent, full-fledged and well maintained fire fighting service of their own. Further, in order to enable quick response to any fire outbreak and to limit the response time to accepted standards, that is, within 5 min, it is necessary that a well trained and adequate fire fighting service is available within the premises under the direct administrative control of power house authorities.

10.2 Turbo Generators and Supporting Structures

10.2.1 In underground powerhouse for fire protection of turbo-generator, fixed water spray system to be provided. In case of surface powerhouse, fixed carbon dioxide extinguishing system backed by hydrant system or fixed water spray system to be provided.

For fire involving large quantities of lubricating oil on turbo generators (in and around bearing housing) fixed water spray system/ hydrant/ portable fire extinguisher system to be provided.

10.2.2 Fixed high velocity water spray systems, the designed to discharge a flow of 10 lpm should completely cover all oil systems, oil piping, pumps, coolers and all similar associated equipment including adjacent floor areas. The water spray systems should be divided into convenient zones, and each zone should have sufficient numbers of projectors to cover the zone adequately. The number and groups of protection zones are related to the size of the turbo generator unit, its lubricating plant and auxiliaries. Typical zone arrangements should cover the areas of Lube oil systems, governor oil system, turbo-generator and steel foundation support legs etc. as applicable. Fire detectors for the zones should be of the quartzoid glass bulb type or combined fixed temperature and rate of heat rise heat detectors as per IS 2175. The heat detectors should be provided at strategic points and arranged to give early warning of the unusually high temperature conditions in the area.

10.2.3 Automatic control of the extinguishing systems in this area is more effective than manual control. However, manual over-ride should also be provided. Zone control deluge should be carefully sited so as to be operable without fire or smoke hazard to the operator, during a fire. This may be achieved by careful location of the valve assemblies away from protection zones, or by enclosing the valves in protective cubicles, at the same time affording the operator a good view of the protected zones. Access routes to control valves should not involve to the operators.

10.2.4 The water spray systems should incorporate isolation facilities so as to enable periodic testing, maintenance, etc.

10.2.5 Normally all cut off valves should be locked in open positions.

10.2.6 A selected number of internal hydrants (landing valves) should be provided, connected to the fixed pressurized fire protection system. These hydrants should be strategically positioned to cover the turbine operating floor as well as the basement areas.

10.2.7 The pressurized fire protection system should have sufficient pressure to allow the generation of low expansion foam for fighting static/running oil fires.

10.2.8 To enable fire fighting to be successfully carried out, facilities must exist for easy smoke dispersal, by provision of sufficient and controllable, top and bottom ventilation.

10.2.9 In event of a fire involving, or close to, a turbine generator or its auxiliaries, it may be safer to shut down the unit so as to limit the damage only to that directly resulting from the fire. The shut down system should be automatic.

10.3 Transformers

10.3.1 No fixed fire protection equipment (such as high velocity water spray) IS required on transformers below 10 MVA in the case of oil filled transformers, with oil capacity of 2000 litres and below. For all other transformers high velocity water spray system should be provided. This system should be separately mounted and designed to take into account the possibility of a transformer explosion. The water spray deluge valve house should be located outside the transformer fire zones and protected from radiant heat and other fire effects. The actuation of this system should be automatic but manual operating valves should also be provided.

10.3.2 Fire barrier wall should be provided between transformers where they are less than 15m apart or where the oil capacity exceeds 2 000 litre.

10.3.3 The transformer should be so designed as to permit the safe testing of the fire protection system, with discharge of water, while on load.

10.3.4 There should be arrangements for containment of the spilled oil. For generator transformers and other large transformers the drainage system as well as the storage pit should be sufficiently large, to accommodate at least the total volume of the oil and an allowable volume of fire fighting water. The drain pipe should be provided with standard type of flame arrestors (*see* IS 11006).

10.3.5 The fire protection systems covering the generator transformers, associated oil conservator tank and cooler batteries should be designed to meet the single risk concept, so that simultaneous deluge over all the three risk zones is possible.

10.3.6 When the transformer is installed near the cable trenches, the gaps in the trench cover plates within a reach or approximate 15 m or so (depending upon the capacity of transformer) should be properly filled with lean mortar so that in the event of explosion in the oil filled equipment, burning oil may not find access into the cable. Entry of the cable duct from the yard into the cable gallery should be effectively sealed with brick work of lean mortar 1:5 to guard against ‘stack-effect’.

10.3.7 Fire extinguishers and fixed fire fighting system for oil filled outdoor transformers should be provided in line with CEA (Measures related to safety and electric supply) Regulations/ OISD-STD-173.

10.3.8.Transformers installed adjacent to sub-station/ buildings shall, where oil capacity does not exceed 2 000 litre, be provided with a layer of 100 mm deep stones of about 40 mm granulation, all around the transformer, for a width of 20 percent of the transformer height or with a minimum width of about 800 mm.

10.3.9.Transformers installed adjacent to sub-station / building shall, where oil capacity exceeds 2,000 Litres of oil in a chamber, be provided with oil containing pits.

10.4 Switch Gear

10.4.1 Gas filled circuit breakers and vacuum breakers (such as sulphur-hexa-fluoride) are the least fire hazardous as compared to oil circuit breakers or air-blast breakers. Hydrant protection should be in close proximity to these risks.

10.4.2 For an enclosed switchgear room without any operating persons, automatic carbon dioxide total flooding extinguishing system is considered preferable to water system. Switch rooms should be provided with controllable ventilators.

10.4.3 All openings for cable entries in the switchgear room should be effectively sealed by use of fire stops (*see* IS 12459).

10.4.4 All switchgear rooms should be kept clear and free from any accumulated debris or flammable material.

10.4.5 The following switch boards may be housed in separate room:

a) 6.6 kV unit switch boards (with separate room for boards of each unit),
b) 6.6 kV station switch boards,
c) 415 V station switch boards, and
d) 415 V unit switch boards.

10.4.6 Switchgear rooms should be pressurized by the ventilation system to prevent ingress of dust. Suitable interlocks should be provided to switch off the pressurized ventilation system before the centralized extinguishing gas system is put into operation.

10.4.7 Smoke detectors of the multi-sensor and optical type should be installed in the switchgear rooms on the cross-zoning principle, with suitable time delay devices incorporated. Proven intelligent fire detection systems (micro-processor based) are preferable.

10.4.8 Fixed gaseous extinguishing system of the local application type will be ideal for extinguishing fires in switchgear systems.

10.4.9 ISI marked Insulating mats as per IS15752 shall be provided in the front and back end of switch boards

10.5 Control Room

10.5.1 All openings for cable entries in the control room should be effectively sealed by use of fire stops (*see* IS 12459).

10.5.2 The rooms should be kept clear and free of any waste material.

10.5.3 The air conditioning system should be automatically switched off before the extinguishing system is put into operation or in the event of fire.

10.5.4 Smoke detectors of the multi-sensor and optical type should be provided in the control room on cross-zoning principle with suitable time delay devices incorporated. Proven intelligent fire protection system (micro-processor based) are preferable.

10.5.5 Entry of cables to the control room buildings shall be through fire resistant multi cable transits (MCTs).

10.5.6 Control room entry shall have double doors. The air curtain facility at inner door

may be considered to prevent any dust entry inside the control room.

10.5.7 The plant /control room communication system shall include some or all of the following facilities as per individual plant requirements:

a) Telephone public address system,
b) Emergency communication system,
c) Radio communication system and
d) Intrinsically safe mobile phones.

10.5.8 The exit doors of control room should be distinctly marked.

10.6 Cable Galleries

10.6.1 The experience of power station cable fires has been that in many cases, several units, if not the whole station, had got seriously affected by a single fire. PVC is not easily flammable but burns freely in fairly high temperature conditions producing copious quantities of dangerous fumes and gases including hydrogen chloride. These gases are toxic and highly corrosive. The cable galleries, separating rooms, etc, should be provided with facilities for ventilation together with means of controlling it from the outside. Apart from the need to clear smoke and toxic gases in the event of a fire, ventilation may also be necessary for temperature control of the galleries or areas.

10.6.2 To limit the spread of fires along cable ways, fire barriers or separation walls should be installed for compartmentisation as mentioned in IS 12459.

10.6.3 Access and exit ways, large enough to allow a man wearing breathing apparatus and carrying other fire fighting equipment, to pass through, should be provided. The distance between such exit ways should not exceed 60m in the cable galleries except in case of vertical cable galleries or tunnels as in case of underground power house. The cable galleries should be provided with automatic fixed fire fighting installations using water, carbon dioxide, inert gas system or high expansion foam. However, water sprinkler system is generally preferred. The design of sprinklers and projectors should ensure that no rack of cables is left unprotected. Multi-sensor smoke detectors & linear heat sensing cables to be used for the automatic fire alarm system. The exit doors should open outwardly.

10.6.4 Where high expansion foam or gas extinguishing systems are used, the system should actuate only after all persons have been evacuated.

10.6.5 Self-contained breathing apparatus sets should be available for ready use by trained personnel, on strategic points near the entry to the cable galleries.

10.6.6 All cable tunnels, galleries, cable ways, etc, must be kept clean and free from all extraneous combustible material.

10.6.7 The means of escape should be clearly indicated and all exit ways must be kept clear. A controlled access procedures should be enforced for cable galleries, tunnels, etc, for employees on regular work or inspection duties.

10.6.8 LHS (Linear heat sensing cable) shall be used for fire detection along EHV cables.

11 WATER SUPPLIES FOR FIRE FIGHTING (EXTERNAL AND INTERNAL HYDRANT SYSTEMS)

11.1 The water supplies for fire fighting for power stations should, by and large, conform to the provisions contained in IS 9668. Those for internal hydrant system should conform to IS 3844 and for external hydrant system to IS 13039. In addition, the requirements given in **11.2** to **11.7** should also be taken into account.

11.2 The water supplies should be planned on the basis of the requirements of the largest fixed fire extinguishing system demand plus the maximum demand from the hydrant mains of not less than 1 800 lpm for a minimum of 2 h duration.

11.3 The fire fighting pumps should be automatic starting with manual stopping.

11.4 The main reservoir should have replenishment arrangement for complete re-filling of the reservoir within an 8 hour period. The re-filling operation should preferably be accomplished automatically.

11.5 The water mains should be looped around the main power block and the pipe sizes should be designed to cater to future expansion needs.

11.6 The interior fire protection mains/risers should be considered as an extension of the yard main and should be provided with at least two valve connections with sectional control valves.

11.7 For the entire power station area universal branch pipes, conforming to IS 2871, should be provided in the hose cabinets, as spray nozzles having shut-off capability will be ideal for use in such premises.

11.8 Hydrant pipes above ground should be avoided as far as possible.

12 MANUAL FIRE ALARM SYSTEM

The entire plant area, including administrative and other buildings should be provided with manual fire alarm system with call boxes deployed at various strategic locations. The system should conform to the requirements given in IS 2189. The control panels of the fire alarm system should be located both in the control room as well as in the fire station control room.

13 EMERGENCY POWER

All generator units required emergency power for operation of the, bearing oil pumps and control units, besides meeting the requirements of emergency services like emergency lighting of all vital areas, means of escape, fire fighting pump, etc. A set of station batteries is a reliable supply for each load. Separate battery banks should be provided for each unit. In addition, emergency stand by power is necessary in the form of diesel generators, these units will provide backup power to the station battery system and should be designed to have capability of sufficient power for automatic and dead start. In addition emergency lamps with adequate illumination should be provided at strategic locations (Such as control room) which should operate automatically on the failure of the main supply.

14 ADDITIONAL FIRE PROTECTION MEASURES

14.1 Some of the special fire protection measures which need consideration for hydro electric power stations are mentioned in **14.2** to **14.5**.

14.2 For oil storage rooms automatic sprinkler/ high velocity water spray systems or portable fire extinguishing system using foam or carbon dioxide should be installed. The low expansion foam extinguishing system should conform to IS 12835 (Part 1).

14.3 Water turbines should have all essential safety device including a fail-safe governor drive mechanism, means to stop the flow of water to the penstock and turbine in the event of failure of the turbine, automatic shut-down of the turbine on development of abnormal conditions, temperatures, etc.

14.4 Air cooled generators of capacity 100 MW and larger should also be protected suitably.

14.5 Water proof lighting fixtures should be provided, wherever the water sprinkler fire fighting system is installed.

15 FIRE PROTECTION FOR POWER PLANTS DURING CONSTRUCTION

15.1 The potential fire hazards during construction of power stations are considerable, and call for observance of stringent fire precautions. An above average level of fire protection is necessary during this phase from the consideration of life safety of the large number of on-site personnel, high value of materials and long duration of the construction period.

15.2 The availability of essential fire protection equipment, and minimization of fire risk during construction activities is particularly important.

15.3 Construction schedules should be coordinated so that planned permanent fire protection systems are installed and placed into service as soon as possible, at least prior to the introduction of any major fire hazards.

15.4 Minimum fire detection and fire extinguishing measures will have to be provided for all locations where fire hazards are present, like storage of construction materials, storage of flammable materials, fire safety of welding and cutting operations and other building operations.

15.5 A fire trained supervisor should be available at the construction site to ensure that all essential fire safety precautions are observed.

15.6 Where practical, the permanent fire hydrant system for the plant should be installed well ahead of the completion of the project so that fire fighting water supplies will be available even during the construction period. Where this is not practicable, a minimum number of water tanks of not less than 1.25 lakh litre capacity, with replenishing arrangements, should be available at strategic locations in the plant area which *can* be utilized as an emergency water supply for fire fighting even after commissioning of the plant. A minimum of 2 h duration water supply for fire fighting should be available at the construction site.

15.7 In addition to the fixed water extinguishing systems, sufficient number of first aid fire fighting equipment like different types of fire extinguishers should be available for deployment at various fire risk areas, as per IS 2190.

16 REQUIREMENTS OF MAJOR FIRE FIGHTING APPLIANCES/EQUIPMENT AND MANPOWER

16.1 On account of the reason that hydra power stations are generally located in relatively remote

areas with hardly any other assisting fire service within a reasonable distance, it is necessary for the power stations to be provided with an independent full-fledged and well maintained fire service of their own. Quick response to a fire outbreak by fire fighting service is vital as it makes a difference between a small fire or a major fire with catastrophic loss. In other words, power station fire brigades should be in a position to tackle a fire, control and extinguish it before any damage is done.

16.2 Major Fire Fighting/Appliances/Equipment

16.2.1 *Scales of Major Appliances/Equipment for Power Stations Installed Capacity Less than 50 MW (Class IV Power Stations).*

There may not be any need for any major fire fighting appliances for generating stations of this category, provided the station is located within 8 km from the nearest municipal/local fire brigade possessing adequate fire fighting appliances. In case it is located at a further distance, or if the municipal fire appliances are not available, a trailer fire pump conforming to IS 944, or a higher capacity portable pump conforming to IS 12717, should be provided with a skeleton fire staff.

16.2.1.1 The power stations should have a hydrant system, and also at least three static water tanks of minimum 1.25 lakh litres capacity deployed at strategic locations.

16.2.1.2 The under mentioned equipment should also be provided:

a) A minimum of 25 lengths of 63 mm dia fire fighting hose of 20 m length each (15 lengths of Type 'A' of IS 636, and 10 lengths conforming to IS 4927).
b) Universal branch pipes conforming to IS 2871 - 4 No.
c) Foam-making branches FB 5X (*see* IS 2097) - 2 No.
d) Foam-making branches FB 10X (*see* IS 2097) - 2 No.
e) Mechanical foam compound (*see* IS 4989) - As required.
f) B.A. sets (positive pressure type) - 4 No.
g) Blower and exhauster for fire-fighting as per IS 941 - 2 No.
h) Water jel blankets (fire blankets) 2 X 1.75 m - 2 No.
j) Water jel blankets (for burns) 1 X 0.75 m - 4 No.
k) Water jel container - 1 No.

16.2.1.3 The above equipment should be equally applicable to load dispatch centres in major distribution stations (220 kV sub-stations and above).

16.2.2 *For Generating Stations of Installed Capacity from 50 MW to less than 200 MW (Class III)*

Sl No.	*Type of Appliances*	*No.*	*Manning Pattern*
(1)	(2)	(3)	(4)
i)	Foam and carbon dioxide tender (as per IS 951)	1	Round the clock
ii)	Water tender Type 'B' (as per IS 950)	1	Reserve
iii)	High capacity portable pump as per IS 12717	1	Reserve
iv)	Portable water/foam monitors	2	(No separate manpower Required)
v)	B.A. sets (positive pressure type)	8 sets	
vi)	High pressure charging set (for B.A. sets)	1	(at HQ)
vii)	Blower and exhauster for fire fighting, as per IS 941	2	
viii)	Water jel blankets – 2 x 1.75 m	4	
ix)	Water jel blankets – 1 x 0.75 m	8	
x)	Water jel container	2	
xi)	Fire proximity suits	2	

16.2.3 *For Generation Stations of Installed Capacity from 200 MW to less than 1000 MW (Class II)*

Sl No.	*Type of Appliances*	*No*	*Manning Pattern*
(1)	(2)	(3)	(4)
i)	Foam and carbon dioxide tender (*see* as per IS 951)	1	Round the clock
ii)	Dry chemical tender 2 000 kg (*see* as per IS 10993)	1	Round the clock
iii)	Water tender Type 'B' (*see* IS 950)	1	Reserve
iv)	High capacity portable pump (*see* IS 12717)	1	Reserve
v)	Portable water/foam monitors	2	(No separate man-power Required)
vi)	13.5 Light alloy extension ladder with rope (IS 4571)	1	-do-

Sl No.	*Type of Appliances*	*No*	*Manning Pattern*
(1)	(2)	(3)	(4)
vii)	B.A. sets (positive pressure type)	18	
viii)	High pressure charging set (for B.A. sets)	1	
ix)	Lighting van	1	
x)	Jeep 4 × 4	1	
xi)	Blower and exhauster	4	
xii)	Water jel blankets – 2 × 1.75 m	8	
xiii)	Water jel blankets – 1 × 0.75 m	16	
xiv)	Water jel container	4	
xv)	Fire proximity suits	4	

16.2.4 *For Generating Stations of Installed Capacity 1000MW and above (Class I)*

Sl No.	*Type of Appliances*	*No.*	*Manning Pattern*
(1)	(2)	(3)	(4)
i)	Foam and carbon dioxide tender (*see* IS 951)	1	Round the clock
ii)	Water tender Type 'B' (*see* IS 950)	1	Round the clock
iii)	Dry chemical tender 2 000 kg (*see* as per IS 10993)	1	Round the clock
iv)	Emergency tender as per (IS 949)	1	As reserve
v)	Portable water/foam monitors	4	Reserve
vi)	13.5 Light alloy extension ladder with Rope (IS 4571)	2	-
vii)	Lighting van	1	
viii)	Jeep 4 × 4	1	
ix)	B.A. sets (positive pressure type)	24 sets	
x)	High pressure charging set (for B.A. sets)	1 set	
xi)	Blower and exhauster (IS 941)	4	
xii)	Water jel blankets – 2 × 1.75 m	16	
xiii)	Water jel blankets – 1 × 0.75 m	32	
xiv)	Water jel container	8	
xv)	Fire proximity suits	6	

NOTE — Considering the large area of the super hydel stations as well as for facilitating quick turn outs, it may be necessary to deploy the operational equipment at two fire stations, a main fire station and a sub-fire stations, both having up to date communication arrangements.

16.3 Requirements of Manpower for Manning Fire-Fighting Appliances

16.3.1 The manpower requirement has to be based on the number of fire fighting appliances to be kept manned round the clock (day and night). The scales of manpower required for each type of appliance should be as per the norms prescribed by the Standing Fire Advisory Council of the Government of India, and also as per guidelines given in IS 6070. The fire crew, computed as per the scales prescribed above, should work in three shifts. A reserve of $33^{1}/_{3}$ percent of the total strength required for shift duties should also be provided, to cater for leave, absence, training requirements, etc. It has to be ensured that the designated strength of crew for each shift is available for speedy turn-out at all times for quick response to fire calls.

16.3.2 For generating stations of installed capacity less than 50 MW the following minimum manpower should be maintained:

a) Assistant station officer : 1 No.
b) Leading firemen : 1 No. (per shift)

The same norms should apply for manpower requirements for load despatch centres and also for major substations.

16.3.2.1 In addition to the full time fire fighting staff, selected members of the security plant staff have also to be imparted basic training in fire fighting/fire prevention duties, so that they can be utilized for fighting duties in an emergency.

16.3.3 For Class III, Class II and Class I category power stations the manpower requirements should be computed as per norms mentioned in **16.3.1**.

16.3.4 In addition to the above, one Fire Station Officer/ Senior Fire Station Officer will also be necessary for each power station, depending upon the category, as overall in-charge of the power station fire brigade for ensuring proper training, control and supervision of the entire fire fighting staff. He will also be responsible for all the fire protection arrangements in the power station.

16.4 Fire Stations

Power stations authorized for full time fire brigades with major fire fighting appliances should have well designed fire stations for housing of appliances and fire fighting staff. They should be so located that the response time is kept to a minimum, not to exceed 5 min. The design of the Fire Stations should conform to the standard Fire Station requirements as prescribed by the Standing Fire Advisory Council.

17 FIRST AID FIRE FIGHTING EQUIPMENT

In the entire power station area, first aid fire fighting equipments like fire extinguishers should be deployed as per the scales prescribed in IS 2190. It is essential that these extinguishers are periodically inspected and maintained in accordance with the provisions contained in IS 2190.

18 FIRE EMERGENCY ORDERS

18.1 Each power station should have a fire emergency plan formulated so as to facilitate organized actions to be taken in case of any fire emergency. Such orders should contain the actions to be taken by staff at various levels, during day-light hours as well as night. These orders should also contain the instructions on fire prevention measures and the fire sighting organization.

18.2 The fire emergency orders should also contain a mutual aid scheme for mobilizing assistance by way of equipment and trained manpower from neighboring units, if available.

18.3 Periodical training programmes/mock fire drills should be conducted so as to check the alertness and efficiency of plant staff as well as fire fighting staff, and records maintained.

ANNEX A

(*Foreword*)

COMMITTEE COMPOSTION

Composition of Safety in Construction, Operation & Intenance of River Valley Projects Sectional Committee, WRD 21

Organisation	*Representative(s)*
NHPC Ltd, Faridabad	Shri Alok Kumar (***Chairman***) Chief General Manager
BEML Ltd, Bengaluru	Representative
Bhakra Beas Management Board, Chandigarh	Member (Irrigation) Director (Dam Safety) (*Alternate*)
Bharat Heavy Electricals Ltd, Bhopal	Representative
Central Board of Irrigation & Power, New Delhi	Shri A. C. Gupta Shri M. L. Baweja (*Alternate*)
Central Electricity Authority, New Delhi	Director (HPM Division) Deputy Y. Director (HPM Division) (*Alternate*)
Central Water Commission, New Delhi	Director (DSM) Director (DSR) (*Alternate*)
Centre For Fir, Explosive & Environment Saftey (CFEES), Delhi	Dr P. K. Rai
Gammon India, Mumbai	Shri M. V. Jatkar Shri Ashish Gupta (*Alternate*)
Geological Survey of India, Kolkata	Dr Saibal Ghosh Shri Manoj Kumar Kaistha (*Alternate*)
HCC Ltd, New Delhi	Shri Avinash Harde Shri Jai Prakash (*Alternate*)
Himachal Pradesh Power Corporation Ltd, Shimla	Er Devendra K. Sharma Er K. K. Goel (*Alternate*)
Indian Institute of Technology Roorkee	Dr Gopal Chauhan
Irrigation Department & C.A.D, Govt of Andhra Pradesh	Shri I. S. N. Raju Shri S. Panduranga Rao (*Alternate*)
Irrigation Department,Govt of Maharashtra, Nashik	Superintendent Engineer (DSO) Executive Engineer (DSO) (*Alternate*)
Irrigation Department, Govt. of Punjab, Chandigarh	Chief Enginer (RSDD) Director Dams (RSDD) (*Alternate*)
Irrigation Department,Govt. of Uttarakhand, Dehradun	Chief Engineer (Ganga Valley) Superintendent Engineer (MB DAM) (*Alternate*)
Larsen & Toubro Limited, Chennai	Shri Amar Pal Singh Shri Sanjay Pajni (*Alternate*)
National Projects Construction Corporation Limited, Faridabad	Shri Mukul Kumar Shri N. P. Prasad (*Alternate*)
National Water Development Agency, New Delhi	Shri N. C. Jain Shri O. P. S Kusheah (*Alternate*)
NHDC Ltd, M.P	Nomination Awaited
NHPC Ltd, Faridabad	Shri Amit Kumar Shri Rajesh Kumar Gupta (*Alternate*)

North Eastern Electric Power Corporation Ltd, Shillong	Shri Rajendra Sharma Shri Binod Chandra Borah (*Alternate*)
NTPC Ltd, Noida	Shri G. L. Huria
Saradar Sarovar Narmada Nigam Ltd, Gandhi Nagar	Shri K. B. Parmar Superintendent Engineer (*Alternate*)
Satluj Jal Vidyut Nigam, Shimla	Shri Arvind Mahajan Shri Ajay Uppal (*Alternate*)
Tamil Nadu Generation And Distribution Corporation Ltd, Chennai	Er N. Murugesan Er V. Gopalakrishnan (*Alternate*)
Tehri Hydro Development Corporation Ltd, Rishikesh	Shri R. K Vishnoi Shri Manoj Sardana (*Alternate*)
UJVN Limited, Uttarakhand	Shri Arvind Kumar Shri Pankaj Kumar (*Alternate*)
Water Resources Department,Govt of Madhya Pradesh, Bhopal	Shri B. C. Purandare Shri R. K. Jain (*Alternate*)
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Member Secretary

Shrimati Lathan Pari
Scientitst 'E' (WRD), BIS

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